

Assistive technology in South East Asia: Status, challenges and way ahead

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Preface

Disability is a global issue with health and human rights dimensions, affecting an estimated 15% of the world's population. Disability is a development priority because of its higher prevalence in low-income countries and because the majority of persons with disabilities live in conditions of poverty. Access to rehabilitation and assistive technology (AT) for people with compromised functionality can enhance quality of life through improved functioning and social inclusion in all facets of life. The World Health Organization (WHO) estimates that 1 billion people (including people with disabilities, older people, people with Non-Communicable Diseases (NCD), people with mental health conditions, and people with gradual functional decline) need assistive technology products (AP). At present, only 10% of the population in need has access to AT. The proportion is likely to be even lower for the member states (MS) of South East Asia Region (SEAR) where it is estimated that at least 15% of the population lives with some degree of compromised functionality. Access to AT is a fundamental human right for everyone to live a productive, dignified and independent life. The adoption of the World Health Assembly (WHA) resolution on improving access to AT (WHA 71.8) highlights the importance of equitable access to AT to ensure social inclusion and community participation supporting the implementation of the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD). This is also in line with Universal Health Coverage (UHC) ("No one left behind!"), and various WHA resolutions on disability, rehabilitation and AT. The recently endorsed resolution (WHA 74.8) calls for realizing the highest attainable standard of health for persons with disabilities. On 23rd July 2021, the United Nations General Assembly (UNGA) adopted its first ever resolution on eye care "Vision for everyone" which too emphasized the need for AT. The WHO South East Asia Regional Office (SEARO) has supported two regional meetings and four country meetings on

disability, rehabilitation and AT; the development of National AT Lists for four MS; has provided support to six MS to carry out rapid Assistive Technology Assessment (rATA); has supported capacity building efforts in the countries on disability and AT; carried out sensitization workshops for media; and is in the process of establishing an “AT Skills Lab” in the MS and equipping them with AT products. There is paucity of credible information and data on the context and variables that impact the “need-demand-supply” triad for AT. The status of AT and various issues related to it in the region – awareness regarding AT, accessibility, affordability, quality, manufacturing and distribution, access to innovative products, level of support from health insurance etc. – are not well-known. These in turn hamper development of appropriate policy guidelines, implementation of disability and rehabilitation programs, as well as availability of affordable and quality AT products. To identify and review the challenges, gaps and missing links in assistive technology, WHO has initiated this project in partnership with the Indian Institute of Technology Delhi and Social Alpha. The project involves primary and secondary research, to develop an understanding of the next steps required in bridging the gaps in knowledge, policy and practice, towards addressing the current challenges for persons with disabilities (PwD) in SEAR.

The primary research involved a workshop with representatives of MS and experts in AT and case studies provided by MS governments, organizations, and WHO. The workshop was conducted virtually, with 6 of the 11 MS participating and providing an overview of the gaps in knowledge and challenges they face with regards to AT. Each participating country was provided 15-30 minutes to present a status report on AT. The workshop also included a keynote by Professor Luc De Witte, providing insights on a 10-point plan to improve the adoption of AT in SEA (Rao & Arun Kumar, 2021).

Keywords: assistive technology, disability, South East Asia

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1. Introduction

This project aims to create a comprehensive understanding of the challenges, gaps and missing links in the field of AT in SEA. The importance of access to AT has been well recognized across the globe, with various developed countries creating significant strides in promoting accessibility to information, built environments and promoting equity in society through AT. However, the same cannot be said for the global south. In this project, we specifically identify challenges that have limited the uptake of AT in South-East Asia, exploring the myriad of challenges in affordability, awareness, economic and social inclusion, access to AT, research, technology and the challenges faced by diverse sections of society, particularly marginalized sections.

To develop a holistic understanding of the gaps and challenges, the project has been structured into three studies. The first study was a systematic literature review of AT in SEA, identifying the challenges as well as the progress made in various sectors across the SEA MS of WHO. The review specifically targets studies conducted in MS, and data identified from MS, providing a closer look at the research that has come out of SEA in the last 20 years on AT. The second study a workshop inviting experts from the MS to provide a perspective of the ground reality on the gaps and challenges of building the AT sector, and the recommendations from MS on tackling these challenges. Representatives were provided a fixed time slot to deliver a presentation on the state of AT in their country and propose ways of building the AT sector. The workshop also had academic experts who provided an external perspective on building the AT sector, as well as pitfalls to avoid while executing this process. The third study involved collecting case studies from entrepreneurial ventures that had developed solutions specifically for SEA and how they were able to tackle the challenge of developing AT in a low-resource setting, contextualized for SEA.

This report serves as an amalgamation of the findings from each of the three studies, addressing 8 key challenges faced by the AT sector, highlighting challenges which need to be resolved to improve access to AT for all. Based on the gaps, challenges and missing links identified, the study concludes with a list of recommendations that can support a systemic development of the AT sector in South-East Asia. The recommendations have been supported with literature, case studies, and evidence from the workshop with MS representatives.

The introductory section provides an overview of AT, its benefits to society and the current state of AT, particularly in the global south. This chapter expands on the need for AT, its role in improving social and economic inclusion, the vision of embedding AT in everyday lives and the need for a contextually relevant approach towards the entire lifecycle of ATs.

1.1 Assistive technology as a health technology

Assistive technology serves to enable healthy, productive, independent and dignified lives, particularly for those with disabilities, non-communicable diseases, persons with gradual functional decline and ageing populations (World Health Organization, 2018). Disabilities often discourage or disturb economic and social inclusion, leading to degradation in physical and mental health. There are various technical solutions available to help alleviate the effects of disabilities (called AT), however, various hurdles limit access to these technologies for 9 out of 10 persons needing them across the world (World Health Organization, 2018). The lack of physical or cognitive abilities makes routine tasks harder and more painful for persons with disabilities. That is because much of the built environment and socio-economic systems have been conceptualised for the majority of the population, which also happens to have few disabilities. The task of crossing a road may be routine for the sighted, but it is often very dangerous for the visually impaired. The task of climbing up or down staircases can be routine for the physically abled, but significantly more difficult for lower-limb amputees and ageing populations. Calculating everyday expenses is an extremely important task, particularly for persons from lower economic classes, and this task becomes much harder for those with learning disabilities, making independent life without support or aid impossible. In much of the developing world, this support comes from family, friends or relatives, making persons with disabilities socially and economically dependent on other members of the community.

For most of these requirements, assistive technology can help reduce the difficulty of routine tasks, reduce the pain or risk of further aggravating the disability, and reduce the burden on other members of the community, providing the user with independent charge of their life and an opportunity to live a dignified life. The role of assistive technology is not just remedial, but also serves to improve the quality of life. Many of us use AT every day without acknowledging the benefits they provide us, such as spectacles, hand-rails on staircases and navigation assistance on smartphones. Furthermore, most of us will use some form of AT at some point in

our lives, either while recovering from illness or injury, to maintain independent life during old age or even to improve productivity or efficiency in various tasks. AT is now an indispensable part of a healthy life and the lack of access to AT significantly deteriorates the quality of life for those who are dependent on external support to live healthy, dignified lives.

1.2 Assistive technology as an integral part of Universal Health Coverage (UHC)

The World Health Organization defines UHC as the provision of essential, quality health services including treatment, prevention and palliative care across the life course for all individuals with a need, without suffering financial hardship (World Health Organization, 2021). The purpose of UHC is to ensure that people receive the care they need to help alleviate deterioration of health from diseases, while ensuring that the cost of care does not push these people into poverty or destroy their future. For any country, a move towards UHC requires systemic change across the care pathways, including improved access to primary care, structuring healthcare financial systems and investment in public health infrastructure to ensure control of communicable diseases as well as prevention of non-communicable diseases.

An important aspect of attaining UHC is the inclusion of PwDs in this scheme. The 71st World Health Assembly recognized AT as a pillar of UHC (Resolution 71.8). It was found that PwDs have a higher need for healthcare than the average individual, because of their disabilities and a need for meeting the same quality of life and standards of living as people without those disabilities. PwDs also form the largest minority group when considering UHC (Hashemi et al., 2017). The aggravated strain on certain parts of the body and mind leads to a more pronounced and frequent need for care, which is often not accessible or affordable for many PwDs. To ensure equity in the process of attaining UHC, AT can help bridge the gap for UHC. Many assistive products help reduce the need for care and increase opportunities for social and economic inclusion of the PwDs, an important aspect of sustaining a good quality of life. Even today, many disabilities are not recognized by countries, and thus the relevant ATs are not recognized or subsidized by the government. Furthermore, while a disability may be recognized and the government provision systems for certain AT may exist, many healthcare facilities are not accessible for the PwDs, making UHC difficult to attain. The lack of suitable policies for UHC as well as for AT make it difficult for PwDs to attain basic facilities of healthcare, education and access to livelihood (Hashemi et al., 2017). On the other hand, a focus on inclusion of PwDs in

the UHC mandate can help include a wider set of minority groups such as ageing populations, ethnic minorities and people with short-term functional disabilities (Kuper & Hanefeld, 2018). A review of 41 statements made by MS at the WHA found that the participating countries agreed on the benefits of improved access to AT enabling better health, development and human rights (Layton et al., 2020). However, the complexity of the challenge was also recognized, with MS stating the need for inter-sectoral partnerships, knowledge sharing and systemic thinking towards the inclusion of PwD in UHC, while weaning off from a charity-based approach to the development of a commercial AT industry (Layton et al., 2020).

1.3 Assistive technology and Quality Adjusted Life Years

The importance of AT for the PwD is well accepted, and the benefits are also apparent for the users. However, the limited resource setting of most healthcare systems across the world requires a careful study of cost-effectiveness of any new technology being used for healthcare. This is typically done by measuring not only the financial impact of procurement of new technology but also of the lifecycle of the product, as well as the costs borne by patients (or the healthcare system) for the use of the technology and any relapse or repeat procedures due to ineffective use of the technology. Quality Adjusted Life Years (QALY) is one such measure used for healthcare economic evaluation studies. QALYs are the time period gained by the patient through the use of a particular health technology over the entire period of the impact of the technology on the user's life. Cost borne by a healthcare system per "quality adjusted life year helps institutions determine the criticality of investing in a particular technology for maximum gains. This method of evaluating healthcare is particularly useful for measuring quality (morbidity) and quantity (mortality) of healthcare outcomes (Bravo Vergel & Sculpher, 2008).

Due to the high number of PwDs in countries – increasing with ageing populations and incidences of non-communicable diseases – affordability becomes a major challenge for healthcare systems and governments to provide AT for PwDs. In this context, QALY is one tool to measure the benefits of investing in AT. Yet, research also suggests that the various tools to conduct QALYs may present differing outcomes, and thus a wider diversity of methods is required to develop a holistic understanding of the impact of the use of AT (Gelderblom & de Witte, 2002; Persson & Husberg, 2012). The use of QALY has been found to be particularly

useful for employers of PwD, to assess the investment required to higher PwD and the returns that can be expected (Joseph & Namboodiri, 2020).

1.4 United Nations Convention on the Rights of Persons with Disabilities

In 2006, the United Nations General Assembly adopted a resolution to ensure equality of rights and to protect the dignity of persons with disabilities. The text came into force in 2008, whereby all parties to the convention were obligated to uphold the principles of the convention, and doing so, uphold the rights of persons with disabilities, including providing them equal opportunities and access to necessary means of dignified living. Among the SEA nations, Timor-Leste has not made any official action on CRPD, and Bhutan is a signatory, while the remaining nations have ratified the convention and have various official policies on the same. These countries are now at various stages of ensuring the rights of persons with disabilities, ranging from laws against discrimination to policies on equal opportunities and the provision of AP. The CRPD and the Standard Rules on the Equalization of Opportunities for Persons with Disabilities (Standard Rules) call for AT interventions to facilitate full enjoyment of human rights. But there is little research from SEAR to support the fulfillment of these requirements (Borg, Larsson, et al., 2012a).

1.5 Equity in assistive technology – the global North and global South

While countries around the world have adopted and ratified the UNCRPD, the implementation of policies and benefit to PwDs is varied. Developed countries, predominantly in the northern hemisphere, have benefitted from economic progress to make notable strides in inclusivity of spaces, knowledge, information and healthcare. The higher proportion of ageing populations and non-communicable disease burden has also helped make AT a priority in many of these countries to ensure economic and social inclusion of maximum members of society. However, the attention to AT in the global south has been evidenced to be drastically lower in comparison, despite bearing a larger share of the burden of PwDs. Studies indicate a paucity of research and innovation on AT for the global south. This study has also found very little credible research which could translate to national or regional policy on improved access to AT for all. The lack of research and innovation has also led to borrowing of solutions created for the global north, without relevant contextual appropriation, leading to abandonment of devices, and poor or

limited implementation of policy on AT. The complexities of context in the global south are such that the “drag and drop” of solutions have failed, and not just in the AT sector, but across various technical and industrial sectors. It is thus evident that such research endeavors are crucial for an evidence-based approach to the development of the AT sector in SEA.

2. Legislation, policy and resolutions

This section provides a brief overview of the policies and legislations in place for AT in the MS of SEAR.

2.1 Indonesia

In Indonesia, Law number 8 necessitates the provision of AT for PWD for the purposes of education, mobility, health requirements and medical rehabilitation, national and local action plans, disability inclusion health services, draft guidelines of standards of AT, nomenclature for AT in district budget plans. The National Health Insurance Scheme reimburses costs for 7 APs, however the reimbursement value remains low. In Indonesia, wheelchairs are not covered by insurance but prosthetics are covered. The roadmap for 2020-2024 focuses on improving health systems, services and training of staff for AT (Rao & Arun Kumar, 2021).

A review-based study on access to education for PwDs in Indonesia found that poor commitments from the local and national governments was one of the factors responsible for poor access to education for PwDs, and subsequently poor access to economic inclusion (Mustika & Rahmayanti, 2019).

2.2 Myanmar

Myanmar became a signatory of the UNCRPD in 2011, and passed the PWD law in 2015. AT services are coordinated through 10 hospitals through the Ministry of Health, Ministry of Defence and the ICRC. Currently they have no national policy on AT (Rao & Arun Kumar, 2021).

2.3 Bangladesh

Bangladesh is a signatory of the UNCRPD and passed the Rights and Protection of Persons with Disabilities Act and the Neurodevelopmental Disability Protection Trust Act in 2013 to safeguard PWDs for physical and cognitive disabilities. The Directorate General of Health Services took initiative to establish the “disability inclusive health services” and the “disability friendly healthcare”. Major challenges remain in implementing the policies effectively (Rao & Arun Kumar, 2021).

2.4 Bhutan

Bhutan pursues a Gross National Happiness Index, encompassing health and psychological well being among nine categories. It has a National policy for persons with disabilities, catering to the needs of AT for mobility impairment, hearing impairment and vision impairment. AT is moderated by the Disability Prevention and Rehabilitation program under the Department of Public Health, Ministry of Health. Major challenges regarding provision of AT remain at the primary care level. Although they have drafted guidelines for the use and procurement of APs, they have not been implemented effectively (Rao & Arun Kumar, 2021).

2.5 India

In terms of legislation, the government enacted the National Trust for Welfare of Persons with Autism, Cerebral Palsy, Mental Retardation and Multiple Disability Act (1999), the Persons with Disability Act (1995) and the Rehabilitation Council of India Act (1992). A national policy for PwD was created in 2004. India also founded seven national level institutes, five composite regional centers, regional rehabilitation centers for persons with spinal injuries, an Indian spinal injury centre, an artificial limbs manufacturing corporation of India and district rehabilitation centers to support the programs for the upliftment and integration of PwDs with society (Sachdeva & Jose, 2010).

The country also provides diverse schemes to support PwDs, such as the Deendayal disabled rehabilitation scheme to support NGOs delivering rehabilitation services, the scheme of Assistance to Disabled persons for Purchase/fitting of aids/appliances (ADIP), national scholarships for pursuing post-matriculation professional and technical courses, national awards for the welfare of PwD, the national handicapped finance and development corporation loans, and funding from the Science and technology project in mission mode for research and development of AT (Sachdeva & Jose, 2010). The Artificial Limbs Manufacturing Corporation of India (ALIMCO) is a public sector undertaking, that is a major organization involved in the implementation of the ADIP scheme through a variety of AT it produces. The products are provided through limb-fitting centres and donation camps, and in turn make ALIMCO the largest distributor of AT in India (Toro-Hernández et al., 2019).

The government offers various concessions for blind individuals such as concessional fares in Indian railways and Air India, no postal charges for blind literature, rebates on telephone

services and income tax, exemption from customs duty on select goods and conveyance allowances, and financial assistance for education (Sachdeva & Jose, 2010).

The District Disability Rehabilitation Centre provides rehabilitation and AT services at the community level through village rehabilitation workers, who are PwDs themselves. This proactive approach to identifying and supporting PwDs is a government initiative under the Ministry of Social Justice and Empowerment, that conducts screening camps when a threshold number of PwDs are identified in a community (Karki et al., 2021).

Studies have found that although India has a system in place to attend to the needs of PwDs (Marasinghe et al., 2015), these services are often delayed significantly due to disconnected services, creating a domino effect on delays in assistance for PwDs (Borade et al., 2021). The 2001 census indicated 75% of all PwDs in India lived in rural areas, 49% were literate, and only 34% employed (Sachdeva & Jose, 2010).

To mitigate the problem of high expenses for PwDs, The Indian government offers prospective AT users medical treatment up to 1,00,000 INR, one free AP, subsidized loans to start a business (Aadhar Yojana) and monthly allowances. It is also mandatory for each government department to allocate at least 5% of their budget for PwDs. Despite these schemes, AT services continue to remain unaffordable for a majority of the PwDs (Karki et al., 2021).

The government provides disability certificates, assisting PwDs in access to monthly pensions, travel concessions, and funding for ATs. But this funding does not always materialize, and communication devices are not eligible for government funding, limiting the access to ATs for persons with intellectual disabilities (Boot et al., 2021; Rao & Arun Kumar, 2021).

The government also has fixed quotas in government institution for the employment of PwDs. Although this provides employment opportunities for PwDs, it often relegates them to certain jobs, and creates a stereotype of the kind of jobs available for them (Pal & Lakshmanan, 2012).

The community-based rehabilitation (CBR) program set up by the government of India has been found to be the primary point of contact for most PwDs with caregivers in India, and has served to improve the health, reduce suffering, discomfort, anxiety for PwDs as well as their caregivers. The study further found that the CBR program provided useful training and improved the knowledge and awareness of disabilities for the care givers. The respondents also found it

easier to participate in social activities outside their homes, received a positive attitude from the society, due to their involvement in the CBR program (Bokalial et al., 2020).

2.6 Nepal

Nepal enacted the Disability Protection and Welfare Act in 1982, which was followed by the Disability Protection and Welfare Regulation in 1994 (Disability Research Centre, 2018). They enacted the CRPD (optional protocol) in 2010, and amended the Disability Protection and Welfare act to the Disability Rights Act in 2017 (after the formalization of the constitution in 2015), focusing particularly on access to health, education and employment for all persons with disabilities. In Nepal, local governments must allocate funding annually for PwDs, and offer monthly allowances for PwDs to purchase AT services and devices (Karki et al., 2021).

2.7 Sri Lanka

Sri Lanka approved a National Policy for Disability in 2004, and a National Action Plan for Disability in 2014. The CRPD was ratified by the Sri Lankan government in 2016. While much of the groundwork in disability assessment of the country happened through these policies, there was little action taken to uplift persons with disabilities through increased access to education, employment or healthcare, as verified by the census in 2012 (Mendis & Perera, 2019). Sri Lanka is undergoing reforms at the primary care level while developing dedicated services for AT at the national level. The funding mechanisms available are insufficient for the need of AT within the country. There is a need for incorporating AT into national policy, enabling a national budget for AT, and strengthening the monitoring and evaluation of PwDs and their requirements for ATs (Rao & Arun Kumar, 2021).

2.8 Thailand

In 1991, Thailand implemented the Rehabilitation of Disabled Persons Act, allowing PwDs to register themselves for a Disability ID, and become entitled to welfare support. In 2007, the Thai Ministry of Education issued a Ministerial regulation (Persons with disabilities education act) on the provision of assistive technology, media, services, and other related support for students with disabilities, regulating the meaning of assistive technology and the rights of PwD to obtain them (T. Lersilp, 2016). T. Lersilp (2016) studied the provision of AT for access to information for learning for six universities in Northern Thailand and found that the universities, had policies in

line with the regulation, but not all devices provided were used. In 2007, the government also enacted the Persons with Disabilities Empowerment Act, enabling PwDs with a valid ID to receive a monthly allowance.

In Thailand, companies with a hundred or more employees need to comply with a mandatory employment quota scheme for PwDs (Cheausuwantavee & Keeratipanthawong, 2021). A study found that only 8% of PwDs were employed in the labour market, thus reflecting poorly on the effectiveness of the Persons with Disabilities Empowerment Act 2007 (Cheausuwantavee & Keeratipanthawong, 2021).

3. Healthy ageing, non-communicable diseases and disabilities

The SEAR consists of diverse populations and requirements of AT. In Indonesia, there is no data available regarding the AT needs for specific sections of the population. WHO estimates that 16% of Myanmar's total population has some form of disability, whereas the rATA survey estimates 33.7% of the population has a disability. These PwDs can be attributed to an ageing population, non-communicable diseases and conflict. Outside the ageing population and those with non-communicable diseases, India accounts for about 280 million PwDs. In Bhutan, 18.6% of children have some form of disability, and they face a growing burden of persons with non-communicable diseases and an ageing population. There are over 14 million PwDs in Bangladesh and Sri Lanka's population of elderly accounts for 12.4% of their total population (Rao & Arun Kumar, 2021).

This section covers the diverse social, economic and cultural implications of the lack of AT and how the provision of AT can benefit PwDs.

3.1 Disability and social inclusion.

The lack of AT can severely affect social and economic inclusion for PwDs, and therefore the quality of life, especially for people from rural areas. A study in a rural block of Tamil Nadu, India, randomly sampled 203 PwDs for quality of life using the WHO-QOL BREF framework. While 37.5% of the sample rated their quality of life as poor, 92.4% often experienced negative feelings. Some of the factors contributing to these ratings included marital status as single, belonging to poor socio-economic status and having a severe disability (Gnanaselvam et al., 2017). A study of 150 patients of spinal cord injuries in Bangladesh found that the type of injury, gender and age and education was a significant predictor of community integrations and life satisfaction levels (Ahmed et al., 2018).

Social exclusion also leads to poor awareness about other health related factors. A study of 100 PwDs at a tertiary care centre in New Delhi found patients with poor awareness of sexual health practices, use of contraceptives, and a prevalence of STIs (U. Agarwal & Muralidhar, 2016). A survey of 99 hearing impaired persons in Nepal found a 38% prevalence of mental health issues, and 24% prevalence of negative environmental influences (Crowe et al., 2016). For intellectual disabilities, these hindrances are compounded by the lack of awareness of the care

giver, and thus lack of access to rehabilitation or AT (Boot et al., 2021). For persons with multiple disabilities, such as those suffering from deafblindness, their lack of communication abilities prevents their participation in society and research which could raise awareness on their needs, such as services, access to AT, and the environmental factors affecting their participation (Jaiswal et al., 2019).

Social exclusion of PwDs often occurs from birth for persons with congenital disabilities. Pal et al., (2013) found that in India, blind people are often excluded, both socially and culturally, from society immediately after acquiring their disability, and individuals even go through primary and secondary education without access to, or awareness of AT. This exclusion also leads to the creation of separate institutions, and restriction of knowledge of AT to support the broader population of the visually impaired (Pal et al., 2013). This kind of social exclusion also affects the parents of PwDs, as the stigma associated with a disability or disorder prevents them from openly talking about it and finding support (Ehsan et al., 2018). In countries like Bangladesh, this stigma stems from various sources including the lack of awareness of the disability. Extended family often blame the parents for producing children with disorders. A survey of 1900 PwDs in Bangladesh found that they often face discrimination in access to healthcare, education and employment, with women also being less likely than men to be well-educated, employed or perceive to be in good health (Ekman et al., 2020).

Although the percolation of ATs in rural areas is increasing, new challenges are emerging with adoption of AT. Stigma continues to be a major deterrent to the use of AT, especially in public spaces. The use of AT tends to draw attention towards PwDs, and result in differential treatment, often inhibiting social inclusion (Borade et al., 2021). There are psychosocial needs which are also not always factored in the design of AT. In SEA, people are required to remove their footwear in religious places. Users of orthotics, are often not comfortable revealing cosmetic or artificial limbs, and thus find it uncomfortable to visit these spaces, despite their beliefs. Furthermore, most cosmetic limbs are not designed to be comfortable on smooth tiled surfaces, and risk slippage, especially if there is a spilled liquid on the floor, which is very common in religious places where water, and oil form important components of rituals (Bapat & Sujatha, 2019).

PwD can feel unhappy at using devices that make them feel different from others make people look down on them. These feelings prevent them from wanting to attend large crowds or

social gatherings. Using assistive devices also make people conscious of their actions, and fearful of failure or injury (Weerasinghe et al., 2015). A study of patients with low vision in Delhi, India found that patients across all age groups referred to a low vision clinic refused to use low vision assistive products for reasons such as stigma, fear of loss of employment and denial of requirement (Sivakumar et al., 2020). A study of hearing impaired patients in Bangladesh found that one in five literate respondents of the study avoided using hearing aids because they thought they would be made fun of (Borg & Östergren, 2015). Users of orthotics were found to be fearful of visiting religious places, movie theatres and spaces which would reveal their disability (Bapat & Sujatha, 2019). However, another study in Bangladesh indicated that users of hearing aids were more likely to report positive attitudes from neighbours, and have less difficulty in making and maintaining relationships with friends and family as compared to non-users of hearing aids (Borg, Östergren, et al., 2012). The overall quality of life may not be recovered after the use of AT. A study of lower-limb amputees in India reported an overall lower quality of life for lower-limb amputees even after use of prostheses, predominantly due to phantom limb pain, residual stump pain, and comorbidities (Sinha et al., 2011).

The ageing population forms a distinct and important part of the PwD community. As they often suffer from multiple chronic diseases and disabilities, they have diverse needs ranging from intensive monitoring of vitals, medication management, and AT for physical, sensorial and cognitive impairments (Motahar et al., 2019). A survey of 300 elderly persons in Chandigarh, India by Malhotra et al. (2014) found that activity limitation increased with age for the study participants, and most participants had problems with vision, mobility and the onset of non-communicable diseases. Similarly, an assistive technology assessment survey in Bangladesh found an increase in populations using AP with increasing age (Pryor et al., 2018).

Despite the challenges, research indicates that the provision of AT improves the participation of PwD in society. In Bangladesh, a study of hearing and mobility impaired persons found that the services for use and maintenance of hearing aids and wheelchairs improved social inclusion of PwDs, thus indicating a need for improved access to these services (Borg, Larsson, et al., 2012b).

3.2 Economic inclusion

The economic inclusion of PwDs continues to be a major challenge in SEA. However, AT has been found to help PwDs reduce dependence on care givers, and increase economic independence (Borade et al., 2021).

A study involving 432 PwDs and 417 employers in Thailand found that over half of the PwD participants had completed secondary school education, but 79% of the PwD participants were unemployed, 13% were self-employed and 8% had labor market jobs. Among the participating employers, 73% indicated their companies had policies for employing PwDs. The participating PwDs and employers felt that appropriate jobs for PwDs were available in the open labor market, which required unskilled labor. PwDs also felt they required housing and transportation support, and accessible working environments provided by their employers. The main point of contradiction between employers and PwDs was found to be in job characteristics. While employers believed PwDs should follow standard policies on job positions, working hours, salaries and welfare needs as compared with persons without disabilities, PwDs felt their job characteristics should be customized based on the disability (Cheausuwantavee & Keeratipanthawong, 2021). A quality-of-life study of lower-limb amputees in India reported 52% of the 622 participants were unemployed, out of which 80% were employed prior to the amputation. Furthermore, 82% of these participants that were employed prior to the amputation reported that the loss of employment was a direct consequence of their amputation (Sinha et al., 2011). A study on wage distribution among PwDs based on the Indonesian Family Life Survey found that not only do PwDs have lower participation in the labor force, but the diagnosis of their disability does not improve their wages, thus putting into question the laws and policies in place to prevent income disparity of PwDs (Caron, 2021).

In terms of economic inclusion, PwDs in India have been found to aspire to work for Multinational corporations, as they provide good income, healthy work environments, and often have dedicated AT and employment opportunities for PwDs. This is further considered an attractive trait among the middle-class in the marriage market as well (Pal & Lakshmanan, 2012). The economic inclusion of PwD not only provides them with a dignified life, but also allows PwD to be active participants in the economic growth and development of the SEAR. ATscale, the global partnership for assistive technology modelled the impact of investing in AT and found that sustained provision of AT such as hearing aids, prostheses, eyeglasses and

wheelchairs in low and middle income countries and investments in the product service systems can generate returns of nine times the invested amount (ATscale, 2020). An assistive technology assessment survey in Bangladesh found that people who were economically active (employed) were 5.5 times more likely to report an unmet need for an AP than people who were economically inactive (unemployed) (Pryor et al., 2018).

3.3 Rural and urban divide

The significant wealth gap and gap in resources between rural and urban areas in SEA stifles access to AT for a large proportion of the PwD population. In India, although AT services are primarily based in urban locations, identification of the needs is often conducted at the community level even in rural areas through ASHA workers, Anganwadi workers and village rehabilitation workers. However, the PwDs then need to go to AT service locations to obtain AT. In Nepal and Bangladesh, the identification of PwDs in rural areas only happens through screening camps. The distances and time involved in getting AT for most rural populations discourages the investment, unless absolutely necessary (Karki et al., 2021). In Indonesia, since the procurement of AT happens through healthcare facilities, and these facilities are primarily in major urban areas, APs often don't reach the rural areas.

Rural areas are increasingly getting access to technology, but that does not always translate to assistance with disabilities. A cross-sectional study of visually impaired children in rural Nepal found that although the children had access to smartphones, they were unable to fully utilize the accessibility features due to limited education and understanding of the technology (Sankhi & Sandnes, 2020). Emerging technologies in SEAR continue to be adaptations of western models, and thus do not fit with the SEA context. The language differences, and the reliance on resources such as electricity and good working environments often relegates the adoption of new technologies to urban spaces which can mirror western notions of development. But the requirements of rural settlements of SEA are often quite different to the AT solutions available in the market (Sharma, 2021).

A major challenge for rural populations, particularly those from poor socio-economic backgrounds is the lack of employment opportunities that can provide healthy living standards. The poor working conditions of labour results in health issues, leading to disabilities and the need for suitable rehabilitation measures. In the Himalayan region of India, women often carry heavy loads across towns on roads with steep inclines and using woven baskets that provide no

back support, leading to musculoskeletal disorders due to wear and tear of the back muscles. These conditions can often be avoided if suitable AT can be provided at affordable rates for tasks like carrying heavy loads (Vishnu et al., 2018).

3.4 Challenges in education

Within SEA nations, education has been the primary means of uplifting entire generations from their socio-economic status, and improving opportunities for dignified living standards.

However, children with disabilities, particularly those without access to AT, continue to face many challenges in completing their education.

A study in Bangladesh sampling 285 hearing impaired and 298 ambulatory impaired persons assessed how users of AT enjoyed human rights in comparison with non-users. They found that users of hearing aids were significantly more likely to report that they could read, had completed primary education and had a high participation in school (Borg, Larsson, et al., 2012a; Borg, Östergren, et al., 2012). The use of poor or faulty APs has been found to limit opportunities for individuals, diminishing access to education (Borade et al., 2021).

Another major challenge in education is the need for written examinations to be eligible for future education or job-related opportunities. The need for a scribe for visually or ambulatory impaired students can be a significant factor in contributing to the examination and in turn, the outcome. There are many requirements on the suitability of the scribe based on their education, the exam being conducted, and the institution hosting the exam. This can take valuable time away from the candidate's preparation, and also affect the outcome of the exam, depending on the scribe's performance (Pal & Lakshmanan, 2012).

In Indonesia, access to education for PwDs is significantly hampered by poor commitments from local and national governments, poor access or awareness of AT and low opportunities for income generation, as found in a review by Mustika & Rahmayanti (2019).

A cross-sectional study in India of 250 visually impaired children attending schools for the blind found that students actively requested for tactile or sound-based AT including a talking watch, braille typewriter, and audio formats. Among vision based AT, students requested for optical magnifiers, electronic magnifiers and large keyboards for computers (S. S. Senjam et al., 2021). Dias et al. (2010) found most schools in their study in South India did not have access to tactile graphics or braille emboss machines, due to the high

costs involved. A cross-sectional study of children with visual impairments attending schools for the blind in Delhi found students could not use braille typewriters even though they would like to, because they could not afford them (S. S. Senjam et al., 2021).

PwDs often face challenges in education which would ordinarily not be considered to be related to their known disability. For example, a study of 48 speech and hearing impaired students in Kolkata, India found that although these students had comparable outcomes in solving numerical mathematical problems as compared with students without disabilities, a significant drop in comparative performance was observed in solving comprehensive mathematical problems, showing a link between language comprehension and their disabilities (Roy, Maiti, Ghosh, Chatterjee, Basak, et al., 2019).

3.5 Environmental factors and universal design

While much of the discourse on AT has been focused on new products, PwD face many issues beyond the confines of their house, in terms of physical access to public spaces. The COVID-19 pandemic has accelerated the transition to digital services, but much of the uneducated and economically weaker sections of society continue to rely on physical access to spaces, even for essential services, but the accessibility of public spaces continues to be a major hindrance. According to Van Hees et al. (2015), the most prevalent environmental impediments to accessing basic healthcare services for PwDs in Nepal were transportation and the attitude of family members and the community.

In the case of AT for learning disabilities, the environment plays an important role in promoting the required training. For children described with learning disabilities, Augmentative and Alternative Communication has been found to be useful approach to help children develop communication skills, provided the appropriate environment for implementation was adhered to (PM et al., 2021). Another study found that the cultural and social beliefs of parents, along with a lack of access to relevant services and systems, limit the exposure of children with cerebral palsy to environments crucial for effective rehabilitation (Jindal et al., 2018).

In the coming years, SEA will develop an increasingly ageing population. While current research focuses on addressing the needs of PwDs, there is very little research on the prevention and mitigation of injury and disability for the ageing populations to come (Marasinghe et al., 2015). Banerjee et al., (2012) found that the inclusion of hand rails in bathrooms can help reduce

pain while bending and improve the quality of life for people with osteoarthritis, which has been found to affect almost 40% of adults over the age of 70%.

Even with access to APs, PwDs can have difficulties accessing built environments, as they are not designed to support AT (Borade et al., 2021; Weerasinghe et al., 2015). A study by (Rajole et al., 2020) found that paraplegics have problems accessing public transport and doing various household tasks. An accessibility audit of a major interstate bus terminal in India found the accessibility compliance of the building to be at 42%, reflecting the challenges in accessibility, safety, security, comfort and convenience for people using wheelchairs, crutches, prosthetics and non-users of AT (Alagappan et al., 2018). A study in Thailand found that PwDs had significant problems accessing local markets due to a lack of suitable AT, including ramps, walkways, accessible services and standards for access (Kutintara et al., 2010). An important source of information for both users and non-users of AT is libraries. Extensive research has been conducted over decades on how libraries can be made more inclusive and accessible for PwDs but many challenges continue to plague the library infrastructure in SEA. Although libraries are now equipped with desktop computers, the staff are often not trained to assist PwDs in accessing the space for appropriate use (Nazim et al., 2021).

A study in India found PwDs to have strong motivations for the use of independent transport, particularly those who were using personal vehicles before acquiring the disability. However a low satisfaction in conducting activities of daily living may affect their opportunities for availing independent transport (Beyene et al., 2012). Users of hearing aids were also more likely to report high use of public transport in comparison with non-users, because of the lack of information on public transport systems in Bangladesh and where information was present, non-users of hearing aids were less educated and thus unable to make use of the information available (Borg, Larsson, et al., 2012a).

3.6 Vulnerable populations

The diverse ethnic, cultural, religious and socio-economic classes in SEA often indicate the need for solutions that are carefully designed to be inclusive for all, regardless of background. Research now indicates that some of these communities are not getting equity in access to AT and equal opportunities for a dignified life.

Pal & Lakshmanan (2015) found that women with disabilities in India often pay more for AT than men, because these purchases are often related to the social networks of the PwD. In their study, it was observed that while a third of the men in the sample had purchased used devices through a friend, less than one in five women could do the same. Similarly, while men frequently changed their subscription plan or changed phones to find more affordable options while maximizing use, these practices were scarce among female users of AT, for whom switching plans or phones would often connote risking the safety of and comfort with a known device. This could be related to wider social circles for men at work and otherwise as compared with the same for women. Due to their limited social circles, women using AT were also found to rely on electronics stores and service providers for repair and maintenance issues as compared to men, who would first connect with their networks, before considering a formal service for the same concerns (Pal & Lakshmanan, 2015).

Rural areas are increasingly getting access to technology, but that does not always translate to assistance with disabilities. A cross-sectional study of visually impaired children in rural Nepal found that although the children had access to smartphones, they were unable to fully utilize the accessibility features due to limited education and understanding of the technology (Sankhi & Sandnes, 2020).

SEA is also home to some of the most remote and inaccessible populations in world; tribal communities. These communities have been isolated and developed unique cultures and traditions, but are not immune to disabilities, particularly those from ageing. A study of 506 elderly people in the tribal region of Khammam, Telangana (India) found that a majority of the elderly were illiterate, hypertensive, consumed tobacco and alcohol and developed mobility related issues with age (Katta et al., 2017). The study mentioned that AT was an unexplored area of research for these population groups.

Among the vulnerable populations, the increasing proportion of the elderly in SEA cannot be ignored. The population of persons over 60 years of age in India is projected to increase from 8% in 2015 to 19% in 2050 (United Nations Population Fund, 2017). Similarly, the percentage of the population of elderly in 2050 in Bangladesh is projected at 22.4%, in Bhutan at 24.1% and in Sri Lanka at 27.4% (United Nations Population Fund, 2017). Furthermore, the elderly population sees a higher female to male sex ration consistently across all states in India.

4. Awareness about assistive technology

Apart from the social stigma and discrimination against PwDs due to their disability, many of them do not know of suitable solutions to overcome their disabilities. Assistive technology continues to be a new and emerging field, with very limited dissipation of knowledge related to AT and APs, particularly in remote environments. Research indicates that the lack of awareness about AT in SEA could be playing a major hindrance in understanding the need for AT and subsequent demand and supply of AT in SEAR.

In Indonesia, the awareness around ATs is dependent on support from WHO, NGOs and universities. In rural areas, people often resort to indigenously made solutions which are non-standard but low cost. Bangladesh faces limited adoption of AT as people are unaware of the benefits it may provide them. There is also a stigma on the adoption of ATs in society (Rao & Arun Kumar, 2021). For hearing aid and wheelchair users in Bangladesh, sources of awareness included community-based rehabilitation workers, doctors, and nurses (Borg & Östergren, 2015). In Bhutan, the lack of awareness on AT is not only at the public level, but also at the governance and leadership levels, limiting the demand of AT. In India, a notable challenge is the limited awareness of AT by the trained personnel for rehabilitation and AT provision. Sri Lanka also faces the problem of a lack of awareness of ATs by PwDs (Rao & Arun Kumar, 2021).

Karki et al., (2021) suggests that when governments in India, Nepal and Bangladesh formulated and implemented policies through AT service providers, it was assumed that the policies will trickle down to the users as well. However, AT users continue to have very little understanding of their rights to these services and changes to products and services (Karki et al., 2021). AT continues to be understood primarily as mobility aids. Users suffering from disabilities are also often in the dark about their rights to AT. There continues to be a lack of mechanisms to inform PwDs about their disabilities and AT to support them (Karki et al., 2021).

In a cross-sectional study of the awareness and attitudes about assistive technology (AT) of school teachers in West Bengal, India, it was evidenced that the schools had inadequate and outdated resources for PwDs. Teachers were also not very aware of how to accommodate and assist students with special needs, even though they were positive of a need for AT in the education setting (Kundu et al., 2020). An assistive technology assessment survey of 4254

persons in Bangladesh found 3.9% of the participants were PwD, while 31.9% of the participants reported some form of functional disability. The survey also found 52.4% of the participants reported that they did not know about APs and hence did not use them (Pryor et al., 2018).

Pryor et al. (2018) found that the unmet AP needs of a population can be characterized in multiple ways. The overall self-assessed unmet need for functional disabilities was found to be 70.7% of the population. 74.7% of the participants who reporting a functional disability felt they did not have an AP for their requirements. This included people who did not have any APs (65.3% of the participants with functional disabilities but no APs), and people who already were using atleast one AP (87.5% of the participants who were using APs). The study further found that people already using APs were more likely to report an unmet need for an AP, than people who had never used APs (Pryor et al., 2018).

A cross-sectional study at a visual rehabilitation clinic of a tertiary eye centre found that although there were 42 different AP known for visually impaired persons (ranging from tactile to sound-based devices), the patients were not aware of most of these devices, and thus did not use most of them as well (S. Senjam et al., 2019). Yet, awareness and use of aids for the visually impaired was found to be of acceptable standards in schools for the blind in a study in Delhi, India (S. S. Senjam et al., 2020).

Elderly in India were found to be well aware of communication and mobility AP, but not as aware about clothing aids, footwear, kitchen aids, and home security systems, for which there is now an increasing demand (Maurya et al., 2019).

With regards to intellectual disabilities, the SEAR continues to lag behind in awareness. In a study with 15 PwD with intellectual disabilities, and 16 providers of AT in India, family acceptance and shame played a major role in inhibiting access to AT. Patients of intellectual disabilities were considered cursed, or were treated as unwanted by their parents, and were isolated from the community, preventing any form of assessment of the disability. There was also stigma from health professionals, limiting the participation of PwDs in consultations. For patients with poor communication skills or other disabilities such as vision or hearing impairment, it was more difficult for AT providers to identify the disability. Furthermore, persons

with intellectual disabilities are unable to voice their own needs, limiting advocacy for AT for intellectual disabilities (Boot et al., 2021).

Although new technologies are emerging rapidly, PwDs are often unaware, as there are no information dissemination networks and support groups to help inform them (Weerasinghe et al., 2015).

5. Affordability of assistive technology

One of the main barriers to the adoption of AT is the financial investment required. In SEA, most AT are available only through out-of-pocket expenditure, and few government subsidy schemes are available or accessible to the majority of PwDs. While the older products are typically of lower quality but more affordable, new products that meet the needs of the PwD are expensive and out of reach for most people (Weerasinghe et al., 2015). This section focuses on the diverse challenges of meeting the cost requirements for owning and using AT in SEA.

5.1 Current status

Most countries in SEAR are dependent on aid from governments and NGO's to make AT affordable. However, due to the significant volume of demand, these funding strategies are unable to meet the majority of the needs of PwDs, who rely on out-of-pocket expenses to support their AT requirements (Karki et al., 2021). India has a limited choice when it comes to affordable AT products, and there is also limited availability in rural areas. Sri Lanka has no standard pricing system for ATs, and a lack of donors to provide products for free. The funding mechanisms offered by the government are also poor and inaccessible (Rao & Arun Kumar, 2021). Under the National Health Insurance Scheme, Indonesia reimburses the price of seven AT products, but the reimbursement amounts are low, and require PwDs to pay from their pockets for a majority of the costs. In Myanmar, ICRC supports PwDs by providing AT for physical rehabilitation, and conducting mobile prosthesis workshops providing prostheses and repair services for victims of conflict. Humanity and Inclusion provides prosthesis repairs, physiotherapy sessions and home adaptations (Rao & Arun Kumar, 2021). In a study of 285 hearing impaired and 298 ambulatory impaired patients in Bangladesh, half of the men, urban dwellers, older respondents and literate respondents had paid the full cost for their hearing aids. Two-thirds of the PwDs who did not have hearing aids or wheelchairs reported that they could not afford it (Borg & Östergren, 2015).

5.2 Challenges

Cost continues to be a major barrier to the adoption of AT. Weerasinghe et al. (2015) found that in a community of PwDs in Kandy, Sri Lanka, individuals found it distressing to not be able to

afford AP on their own. Poverty also delayed access to AT available for free through donors. Sharma (2021) found that AT for visually impaired was often very expensive and not within economic reach for most. This made many individuals resort to using pirated softwares or softwares within the free license or trial period. In an assistive technology assessment survey of 4254 adults in Bangladesh, 44.8% of the people reporting a self-assessed unmet need for a functional disability found affordability to be the reason for not using APs (Pryor et al., 2018).

AT also tends to add to investments for people with PwDs, as compared with people who are able to meet the requirements of their profession without AT. Pal & Lakshmanan (2015) found that in a sample of 21 PwDs participating in a survey on social and economic access, the average respondent paid above the national median showroom price for mobile phones, to avail features such as screen-readers, which were often not available on the lower end models. A survey of 29 users of orthotics in India found that the cosmetic foot provided did not fit standard shoe sizes, and so the users needed custom-made footwear for the cosmetic feet, which would cost more than footwear that was available in the markets (Bapat & Sujatha, 2019). A survey in 2012 of persons with visual impairment found that the most ubiquitous screen reading software JAWS costed the user a license fee of \$1000, which was the same as the average per capita annual income in India, thus making it unaffordable for the average user. However, since this was the most well-known AT for this purpose, PwDs invested in pirated versions, costing them a fraction of the price (McCarthy et al., 2012). If PwDs only add more costs for employers than persons who are able to meet the job requirements without AT, then there is no economic case for hiring PwDs, if other persons are available who are better value for the company's money.

The AT available to most PwDs in SEA are often the most affordable ones, and the ones which fall under a subsidy scheme that is easily accessible, but the affordability often leads to compromises in quality and design. A survey of 29 orthotics users in India found that most users complained of torn garments because of sharp edges on the orthosis. The users also complained of difficulties in walking on sandy or muddy surfaces, inability to ride bicycles, and the inability to kneel down. Furthermore, users complained of joint pain, abrasions on the skin, sweating and the resultant odor as problematic in use of the orthoses (Bapat & Sujatha, 2019).

6. Assessment and training of personnel

The ecosystem of AT has been created out of a need from PwDs, but through the combined efforts of many stakeholders, including rehabilitation workers, anganwadi workers, and health service providers at the community level, identifying persons and their specific needs. These stakeholders form a crucial link in the supply chain of AT, both at the need assessment level as well as the delivery of AP. This section details the various challenges in the training and employment of personnel for linking PwDs with AT, and the systemic challenges in building this ecosystem.

6.1 Current status

Indonesia has very limited resources for training of healthcare staff on AT. Currently, ICRC supports personnel by providing job trainings and scholarships for rehabilitation professionals to study abroad. Bangladesh suffers from a lack of workers trained in AT. Bhutan has two training partnerships with WHO on wheelchair specifications since 2016. India has limited data to assess the needs and barriers to training of personnel on AT. The number of trained personnel is insufficient for the population of PwDs, and there is no structured training available for AT. The current training curriculum is not aligned with the needs and the context (Rao & Arun Kumar, 2021).

A study by Borade et al. (2021) found that PwDs in Pune, India found health service providers to be ignorant of the needs of PwDs. Furthermore, poor coordination between available services meant that services were often severely delayed (Borade et al., 2021). Khan et al. (2020) found that although Bangladesh has 50 AP in their Assistive Products List, rehabilitation professionals know only 23 of them on an average. Furthermore, these professionals also did not know of any databases of AP available. A study involving 16 rehabilitation service providers in India found that for complex or multiple disabilities like deafblindness, there were multiple factors limiting rehabilitation including lack of awareness among rehabilitation service providers stigma associated with the disability, lack of resources to provide assistance and challenges in communication with the PwDs (Jaiswal et al., 2022).

The lack of trained personnel also affects the education of PwDs. A cross-sectional study of visually impaired students attending schools for the blind in Delhi found that students

perceived the lack of trainers in AT to be a barrier to their access to education (S. S. Senjam et al., 2021).

A major concern for PwDs is the lack of services for AP maintenance, repair and upgradation. The services are either not available locally, or very expensive for routine requirements (Boot et al., 2021; Borade et al., 2021; Weerasinghe et al., 2015). Use of AP can be a daily requirement for many PwDs to ensure social and economic inclusion, but for those from low-income groups, taking time off for repair and maintenance requirements can impact their income. A survey of 29 users of orthotics in India found a frequent need for maintenance (as often as every six months) of the products due to broken fasteners, torn straps and worn out padding (Bapat & Sujatha, 2019).

6.2 AT personnel and capacity building

In the case of intellectual disabilities, the care giver is often the focal point of all assistance for the PwD. In these cases, it is vital for the availability of personnel who can train care givers to support PwDs. Training of care givers and users of AT is also essential to reduce abandonment rates of AT and enable users to fully benefit from the technology (Boot et al., 2021).

A study of caregivers and care professionals for Autism Spectrum Disorder found that parents of the PwD often felt a disconnect in the social hierarchy between them and the care professional, and so did not communicate effectively regarding the PwD and their needs. While parents would like discussions about the needs of their child, doctors often do not have the time for extensive talks and tend to reduce the conversation to a lecture, limiting the communication and potential care requirements of the PwD (Ehsan et al., 2018).

A study of twenty public, government-aided and government schools found that schools employed only the minimum mandate of one special education teacher. The special education teacher was in charge of identifying learning disabilities among all students, performing the required tests for early prognosis of learning disabilities in students and ensuring the students with special needs (2-3% of all children) could be assimilated both socially and academically with the cohort (Dhingra et al., 2019).

6.3 Standards in training of personnel

In a survey of 250 practicing physiotherapists in India, Gururaj et al. (2021) found that nearly 86% of the respondents reported that they did not follow standard guidelines for gait

rehabilitation for stroke victims. The authors concluded a lack of evidence to develop standardized guidelines for practice in the Indian context, and a prevalence of on-the-job development of practice for stroke rehabilitation.

In Bangladesh, there are no standard protocols for the interventions and trainings for neurodevelopmental disorders such as Autism Spectrum Disorder. The care givers, primarily psychiatrists and psychologists, follow the UK and American psychiatric practice guidelines for the same (Ehsan et al., 2018). The study, which involved interviews and focus groups with 28 care professionals, and 18 parents found that no reliable information was available on appropriate care practices.

7. Access and provisioning of AT

Since the development of policies for disabilities in various SEA countries, and the evaluation of PwDs through national census, countries are now more informed about the need for ATs.

However, the access to ATs for a significant portion of PwDs continues to be a major hurdle. The poor distribution of resources, and the complex supply chain network creates major delays while bureaucracy stifles innovation and decentralization of the supply network for ATs. This section highlights some of the major challenges across SEA in access to ATs for PwDs.

7.1 Need-demand-supply-impact

Rural areas are increasingly getting access to technology, but that does not always translate to assistance with disabilities. A cross-sectional study of visually impaired children in rural Nepal found that although the children had access to smartphones, they were unable to fully utilize the accessibility features due to limited education and understanding of the technology (Sankhi & Sandnes, 2020).

One of the challenges affecting the need-versus-supply parameters is the discrepancies between self-reporting and clinical assessment of AP need. A population-based survey of vision, hearing and musculoskeletal impairment assessment found 60 % of people clinically assessed to need distance glasses did not self-report a need, whereas 75% of those who self-reported a need for distance glasses were clinically assessed to not require one (Boggs et al., 2021).

There continues to be poor reporting of the demand for ATs because the marginalization and exclusion of PwDs from society means that they are often invisible and unaccounted for (Pal et al., 2013). This exclusion from society is also because of a lack of awareness of the rest of the community of ATs for PwDs. Companies also often refuse to invest in AT, and thus prevent employment opportunities for PwD. Thus, PwDs often spend many years without an understanding of the technology that exists and is accessible to help regain certain abilities, and improve their sense of independence and self-worth (Pal et al., 2013).

A study involving 25 PwDs in Pune, India found that access to AT was significantly delayed by government bureaucracy, and apathy on the part of health service providers. The repeated requests for AT by PwDs was often met with no response, leading to significant investment in time, effort and money, and producing no benefits. To avoid the hassle of going through government procurement channels, PwDs often resorted to out-of-pocket expenses to

meet their AT requirements, but this was very expensive and not an option for most PwDs (Borade et al., 2021).

For children with disabilities and/or disorders, access to AT depends significantly on the initiative of parents. But parents of lower socioeconomic strata often choose not to invest in AT for a variety of reasons, including assuming that the child may not be able to become independent and thus rely on begging for income (Ehsan et al., 2018). A cross sectional study in Delhi of students with visual impairments attending schools for the blind found that students perceived the non-availability of AT to be the main barrier to their education. In schools where AT was available, it was either not in sufficient quantities, or the products were broken and unusable (S. S. Senjam et al., 2021). The students also felt that the need for AT did not resonate with the school.

While APs may help improve the quality of life for PwDs, they often do not guarantee access to built environments. The lack of suitable infrastructure can be a major hurdle for PwDs to access public buildings, spaces, transport, and amenities such as healthcare and toilets. This can further reduce opportunities for social and economic inclusion for PwDs (Borade et al., 2021; Weerasinghe et al., 2015). The lack of assistive technology at libraries limits access to information and education for PwDs, and this lack of access has been well documented in literature (Bhardwaj, 2018; R. R. Patil & Kumbar, 2020; Sanaman & Kumar, 2014). A study involving a survey of 185 universities in India found that almost 4 out of 5 universities did not have the required AT to support library access for persons with visual impairments, such as accessible websites, e-resources, private study rooms, tactile pathways, magnifiers, and accessible printers and scanners (Dodamani & Dodamani, 2019).

Contextually relevant research on needs and requirements of PwDs continues to be scarce, thus limiting the advancement of innovation and research on new products (Jafar & Nagesh, 2021). In the coming years, SEA will develop an increasingly ageing population. The need for assistive technology by the elderly is well documented, with nearly 85% of all elderly needing some form of assistive technology in India (Maurya et al., 2019). While current research focuses on addressing the needs of PwDs, there is very little research on the prevention and mitigation of injury and disability for the ageing populations to come (Marasinghe et al., 2015).

7.2 Dissemination models

The demand continues to be larger than the supply, and so organizations often have to prioritise cases based on the severity of the disability, leaving many individuals unable to procure APs (Weerasinghe et al., 2015). Due to limited dissemination systems, new technology is often unable to reach populations outside of important urban hubs (Weerasinghe et al., 2015). Pryor et al. (2018) found that almost half of their assistive technology assessment survey participants who used APs (46%) relied on self-made, homemade or APs made by a family member. Other sources for APs included hospitals (17.5%), local markets (11.6%), other health facilities (3.76%). Government provision of APs was found to account for only 2.2% of the AP users (Pryor et al., 2018).

7.3 Role of government and social organizations

In Indonesia, 91% of all PwDs do not have access to AT, even through the social protection system. The procurement system is highly fragmented, resulting in low volumes of AP procured (Rao & Arun Kumar, 2021). In Myanmar, the government does not adequately support provision, distribution or access to AT. In Bhutan, the major challenge with regards to access to AT is at the primary care level (Rao & Arun Kumar, 2021). In Bangladesh, a study comprising of 285 people with hearing impairment and 298 people with ambulatory impairment found only about 1% of the PwDs received their APs from government facilities, while two-third of the users of hearing aids and three fourth of the users of wheelchairs got their APs from NGO facilities. Other sources for wheelchairs included community people, clubs and volunteer organizations (Borg & Östergren, 2015).

In a joint assessment of Nepal, India, and Bangladesh, AT service supply in all three countries were evidenced to be inadequate. In India, the service quality varies from state to state. AT is prescribed to PwDs based on strict criteria on the degree of the disability. Within those who are prescribed ATs, many cannot afford the devices, but the government does not support all PwDs with financial aid for their devices. In Bangladesh, although the demand for ATs is high, the supply is not sufficient for the demand (Karki et al., 2021).

There are also gaps in the government policies and the current practices in various countries. Bangladesh has 50 products listed in the Assistive Products List, but only 23 are available in the country, and none of them support cognitive disabilities (Khan et al., 2020).

Government web platforms in India do not meet global accessibility standards, and are thus inaccessible for visually impaired users (Sharma, 2021).

A major limitation in planning for AT resources in SEA is the lack of information management about PwDs, their AT requirements and their socio-economic status. A study in Thailand found that out of 289 PwDs identified in an area, only gender and the devices owned was known about these persons. Due to different policies for AT provision applying in different areas, and different organizations being responsible for providing ATs, the lack of a cohesive information management system means that there is no clear understanding of the PwD needs, and hence no system of planning for future needs (S. Lersilp, Putthinoi, & Okahashi, 2018).

7.4 Access to healthcare for PwDs

As many of the PwDs become enlisted for disability benefits through prescription from healthcare institutions, access to healthcare becomes an important gateway to access to AT. However, a lack of access to healthcare can mean many PwDs, suffer debilitating conditions, and fail to benefit from well-established schemes and policies for PwDs. Some of the challenges associated with access to healthcare have been provided in this section.

According to Van Hees et al. (2015), the most prevalent environmental impediments to accessing basic healthcare services for PwDs in Nepal were transportation and the attitude of family members and the community. Financial impediments included a lack of finances for health expenses, difficulties in creating an income by individuals with disabilities themselves, and poor socioeconomic backgrounds. The family's attitude and drive to seek healthcare was also influenced by the person's low self-esteem (Van Hees et al., 2015).

The limited access to healthcare also spells the increasing population of PwDs through congenital disorders and diseases undiagnosed during pregnancy. Pregnant women in rural areas are unable to get regular check-ups at the early stages of pregnancy, and identify any abnormalities in the foetus. Early check-ups can be vital in promoting a healthy pregnancy for the mother and the child, and reduce complications at birth, but these services are limited in rural areas and may contribute to the occurrence of development disorders in children (Megalingam et al., 2013).

In many SEA countries, the caregiver or care professional for many of the disabilities is a clinician based out of a healthcare institution. Thus, access to these institutions is vital for

continued care and regular assessments of the needs of PwDs. Furthermore, most patients and caregivers do not maintain longitudinal records of the care provided and the progress made by the PwD in rehabilitation and training. This serves as a major hurdle for PwDs to receive appropriate care, especially if the care provider changes (Ehsan et al., 2018).

Many PwDs acquire their ATs from the local pharmacy or medical shop, and thus often manage their disability with products that are either not their size, or not comfortable. Since there is a lack of awareness that AT can be obtained through an assessment with a health professional, PwDs are unaware of the concept of customized ATs for their needs. Thus, the poor fit or discomfort of using a non-customized product often leads to abandonment of the AT itself (Boot et al., 2021).

8. Enabling technologies

The advancement of technology has been critical for the design of inclusive products and services which help PwDs overcome their disabilities and become active contributors to society. The digital revolution has further accelerated access to knowledge and services, previously incomprehensible to PwDs. Governments and societies are constantly attempting and failing to keep pace with new technologies and their abilities to improve lives. This section explores the role of new technologies in AT, and the barriers to their adoption by the PwD community.

Due to limited dissemination networks, new technologies often fail to reach communities in need of them (Weerasinghe et al., 2015). This forms a cycle of dependency wherein PwDs are dependent on their networks to gain awareness and access to AT, which in turn allows them to access diverse networks (Pal & Lakshmanan, 2015). New technologies, when accepted by people as a useful approach to care for PwDs, are not adopted because they are often not tested in relevant contexts for suitability and usefulness (Ehsan et al., 2018).

The COVID-19 pandemic has created a major shift in modes of communication and employment, with companies offering remote working options to employees. This has led to an increase in use of remote access technology as well, primarily in information and communication technology and the adoption of artificial intelligence to support rapid improvement in quality and convenience for users. Through the adoption of these technologies new challenges have emerged. A study involving 25 visually impaired teachers in higher education in India reported that despite the improvement in screen reader technology, they were found to be more compatible with desktop platforms than mobile platforms. There were also challenges in languages apart from English, as many of these systems have not been trained in regional languages, which are often the primary mode of communication in SEAR. In India, despite the transition to digital systems for remote learning, most evaluations are still conducted through hand-written media which are scanned and submitted to teachers. The assistive technology is unable to decipher hand-written text, thus requiring assistance of sighted individuals (Sharma, 2021).

The awareness of new technologies also continues to be scarce, with most awareness happening through word-of-mouth. Although rapid changes are happening in the field of AT, very little communication is happening through formalized channels to the intended audience, leading to limited adoption of these technologies (Sharma, 2021). Emerging technologies in SEAR continue to be adaptations of western models, and thus do not fit with Indian context. The language barriers, and the reliance on resources such as electricity and good working environments often relegates the adoption of new technologies in urban spaces which can mirror western notions of development (Sharma, 2021).

There is also a need to support care professionals with innovations in management of care protocols provided by caregivers from diverse regional, cultural and linguistic backgrounds. A study in Bangladesh reported that care professionals face difficulties in assessing the diagnoses and treatment prescribed to a PwD by care givers using different language dialects, and the caregivers would appreciate a standardization of nomenclature for describing care protocols which are linguistically appropriate for the region (Ehsan et al., 2018).

There are few, if any, national or local government programmes that look into supporting the imminent ageing population of SEAR (Marasinghe et al., 2015). In certain regions of India, the overall expenses of implementing ambient assisted living (AAL) systems with modern smart home gadgets are still too expensive for the elderly. The advantages of these technology tools, such as increased safety, security, and assistance with activities of daily living (ADLs), are not widely understood or communicated to the elderly. As a result, their capacity to adopt such technology is limited by the lack of awareness (Triboan & Meggi, 2019).

9. Recommendations and the way forward

Based on the challenges identified through stakeholder workshops, literature reviews and consultations with enterprises working towards the improvement of the AT ecosystem, a few recommendations have been made to support the development of a competitive AT market. These recommendations have been interspersed with case studies of successful AT outcomes for various disabilities, which can be used as examples of models for the establishment of a commercial AT industry.

9.1 Narrowing the rural/urban divide

Provision of some services could be made digital through mobile platforms, and utilizing e-consultation services and doorstep delivery schemes for APs (Boot et al., 2021). PwDs in Indian farming communities have conventionally played no productive role. But this can change with the application of information technology in farming practices, providing PwDs with management roles to make up for their inability to contribute to labour roles (D. Singh et al., 2016).

XL Cinema is an Indian mobile app-based start-up which leverages the power of digital connectivity through smartphones, to reach a large user base of people with visual impairments providing them access to audio description across movies & shows in multiple Indian regional languages. It started as an application to address the lack of versions of various English/Hindi entertainment content in other Indian regional languages, and eventually the founders realised a substantial use case of their product for people with visual impairments. XL Cinema does not have separate applications for VI (visually impaired) and sighted users. Instead, it has a toggle button within the same application. The user installs only one common app, regardless of their visual ability. The app then auto-detects if the user is visually impaired by tracking if the talk-back feature is on in the user's phone while accessing the XL Cinema app. VI users are highly likely to be using talk-back; once the app detects that it is on, the user gets redirected to a different screen with UI/UX catering to VI requirements. Hence, XL Cinema is able to automate customization through the auto-detection technology, while also reaching a wide base of 30,000 VI users with optimistic growth projections.

New products need to be designed for low-resource settings which are usable in rural areas and can be maintained without needing specialist training and equipment. A study in India proposed a mobile ultrasound scanning system for pregnant women in rural areas which could help identify abnormalities in the health of the mother and foetus at the early stages of pregnancy to reduce complications at a later stage (Megalingam et al., 2013). The Rehabilitation Engineering and Assistive Technology Institute (REAT), Thailand has been developing digital hearing aides for rural populations. Some of the desirable features they identify for this audience include cost-effectiveness, ease of use and maintenance, and fully digital processing capabilities (Israsena et al., 2009).

New technologies need to be developed suited to the contexts of rural settlements of SEA, where luxuries such as clean drinking water, and continuous supply of electricity is not always accessible (Sharma, 2021). For the tribal communities of SEA, AT and disabilities continue to be unexplored areas of research (Katta et al., 2017). For these populations, AT must factor illiteracy, remote habitats, and different cultural and traditional practices which define their way of life.

While new technologies can help improve access to AT for rural populations, systemic change is also required in the form of scalable service models and leadership from clinical experts in promoting AT for rehabilitation purposes (Israsena et al., 2009). To entertain the concept of improved living standards, people in rural areas need to be made aware of AT and its benefits. This can happen through regular updates of the list of AP available at the local government and health centres. Primary healthcare workers need to be trained to assess and recommend AT for PwDs. Local governments need a budget for procurement and distribution of AT, and set up provision centres that help users understand maintenance and usage practices. Finally, to build an ecosystem around these products, local manufacturers must be encouraged to create indigenous AP and support the community through the production and sale of AP.

9.2 Education

Students with known disabilities must be encouraged to embrace ATs that help meet their educational requirements rather than adjust to conventional modes of education. This also means that educational institutions should regularly assess the need for ATs, and focus on modifying curricula for students with special needs that cater to their holistic development (Roy, Maiti, Ghosh, Chatterjee, Basak, et al., 2019; S. Senjam et al., 2019). This has also been demonstrated

by India et al. (2020) through their study of play-based approaches to develop computational thinking for children with vision impairment, by Nisansala & Morawaka (2019) in their study of using gamification to improve learning outcomes for children with intellectual disabilities, and by Poobrasert & Satsutthi, (2020) in their study of developing a novel system to enhance story-writing and vocabulary for children with learning disabilities. Furthermore, S. Lersilp, Putthinoi, & Lersilp (2018) found in a survey of 116 students of 18 years or below with disabilities that most students did not need AP for cultural, recreational or sports requirements, and primarily considered AP to be facilitators for their educational requirements.

CogniAble is an Indian startup attempting to address the following problems for development disorders: lack of early detection & intervention, prohibitive costs of healthcare services, lack of accessibility, lack of clinical experts and human bias in detection and intervention. It is a machine learning driven assistive technology for early detection and affordable treatment of Autism Spectrum Disorder. CogniAble app leverages Computer Vision to conduct video assessments of children & ML based analysis of written user responses to generate Autism detection outcomes. Additionally it provides automatic ML based updating of personalized treatment plans for each child based on their recorded progress data on the app.

New technologies need to be used to create learning methodologies catered towards PwDs, as exemplified by the braille learning applications created and tested in Bangladesh (Nahar et al., 2015, 2020), the tactile image creation software proposed by Dias et al., (2010), the web-based learning platform for children with down syndrome proposed by Wellala et al. (2020) and the digital application for cognitive development of persons with speech and hearing impaired (Roy, Maiti, Ghosh, Chatterjee, Basak, et al., 2019). Furthermore, where possible, new technology should be leveraged to automate aspects of AT which are currently difficult and need external personnel, such as teaching children with vision impairment to read braille (Dias et al., 2009), tools to automate translation of written text to sign language to aid the deaf-mute population (Deb et al., 2018), tools for text-to speech conversion for the visually impaired (Govardanam et al., 2015), augmented reality based applications for assisted learning for students with learning disabilities (Vinumol et al., 2013) and multimedia-based platforms for

assisted learning for persons with hearing impairments (Poobrasert & Cercone, 2013; Roy, Maiti, Ghosh, Chatterjee, & Ghosh, 2019).

While much of the focus in AT has been on empowering PwD with AT for making independent and informed decisions and improving access to information, more work is required to make the built environment accessible. This can leverage existing improvements in technology, such as indoor and outdoor navigation systems for the visually impaired (Dutta et al., 2018; P. Patil & Sonawane, 2017; Shaikh et al., 2017). All government institutions must be equipped with AT to support access to all public spaces for PwDs. Any government tendering of projects must include accessibility as part of the design process. Governments should also create blue-prints of inclusive towns and cities and disseminate to local governments through training programs.

To provide assistive technology in special education schools, S. Lersilp et al. (2015) proposed a five point model developed with key informants as follows; 1. Collaboration between organizations, schools, parents of students and students in decision making, training and using of AT; 2. Holistic understanding of the students' needs, including daily living, education, leisure and socialization; 3. Independent management of AT in schools, including giving teachers access and authority to suggest means of training and engaging parents with the students' AT use; learning systems to educate caregivers on use and maintenance of AT; and 5. Provision of an AT Centre that can evaluate the use and need of ATs. This five-point framework can be accompanied with training of teachers for meeting educational needs of diverse PwDs.

9.3 Health and well being

It is clear that while many challenges continue to exist for PwDs, the access to AT significantly improves the quality of life for many individuals, and improves opportunities for social and economic inclusion (Borade et al., 2021). In an assistive technology assessment survey of 4254 adults in Bangladesh, it was found that 75.1% of AP users found that their APs to meet their self-perceived needs (Pryor et al., 2018). Regular monitoring by governments of usage of ATs and challenges faced by users as well as regular assessment of the impact of ATs must be made an important criterion for the evaluation of future needs in this sector.

ATs in SEA have received little attention and continue to support few disabilities, and fewer people. To ensure diversity in product portfolios, it is essential for SEA countries to create and update essential assistive product lists. Local manufacturers need to be incentivized to invest

and produce AP. New products must focus on holistic improvement in quality of life rather than replacing a disability with a reduced ability. Product standards must be developed and established so quality can be controlled, and maintenance and servicing centres can operate independently. A feedback system should be developed to ensure use statistics and complaints are addressed and products are continuously improved.

CreAID Labs, is an Indian start-up that uses 3-D printing and thermoforming technologies to manufacture custom splints in the orthotics space. Their custom splints are 3-D printed as flat apparatus, which is delivered to the user in a small-sized packet. The installation process is done using thermoforming technology, where the splint flat apparatus is heated and molded according to the user's hand. The process only takes 15 minutes.

Orthotists who have rehabilitation centers, where patients are sent by doctors after prescribing the splints are CreAID's key partners. Current practice for orthotists to make a custom splint is cumbersome and takes 2-3 days. CreAID simplifies this process substantially by giving the apparatus in one small packet, which the rehab staff can take to the patient's home and installation can be done within 15 minutes with its 3-D printed thermoforming enabled custom splints. Hence, the rehab center does not need to allocate any space, machinery, or 2 days' time, reducing their costs drastically and making their operations efficient.

It is encouraging to see that under the roadmap for disability inclusion 2020-2024, Indonesia has drafted seven action points for improving access to AT for PwDs, including development of information systems, health systems, services and training of staff (Rao & Arun Kumar, 2021).

Despite the fact that AT for ageing populations has gotten some attention in LMICs, as evidenced by the limited literature results, there is a need for a comprehensive, integrated health and social system strategy to expand the existing availability of AT for ageing people in LMICs (Marasinghe et al., 2015).

9.4 Affordability of AT

AT currently operates on a charity model in SEA, supported by government subsidies, government supported manufacturing, and distribution through healthcare facilities. However,

this model has made limited progress in providing ATs to PwDs across SEA. The alternative is to empower PwDs to become consumers of AT. By creating a market for ATs, manufacturers will have greater incentive in designing for specific audiences, controlling quality and creating feedback mechanisms to improve the products. Products will also be priced as per the purchasing power of the audience. The government can help setup these investment platforms and support manufacturers through subsidies on capital investment. The government can continue insurance and subsidy models for the lower income groups. These manufacturing hubs can also support employment of PwD, creating jobs and economic opportunities.

Most AT developed for the elderly often do not factor the lack of income that this age group has to endure. Thus, devices that are functional but exorbitantly priced are scarcely adopted.

The application of new technologies can also help reduce the costs of AT. A study by S. K. Singh et al. (2020) applied machine learning algorithms to reduce the cost of testing individual cells in refreshable braille displays. Nahar et al. (2019) proposed an application to make learning of braille accessible to visually impaired students without significant investments in assistive technology. Pan-ngum et al. (2013) proposed a frequency modulated assistive listening system for children with hearing impairment attending school as a low-cost alternative to existing assistive listening systems. Dias et al. (2010) proposed a software to generate tactile graphics using braille embossing machines to encourage spatial learning and understanding among visually impaired children.

Vispala, an Indian startup uses 3-D printers to make prosthetics with skin toned gloves and metal support parts. This solves the critical issue of making customized prosthetics affordable. They have partnered with 20-25 of the biggest NGOs in India in this space and they supply their products to them, who then distribute to the end-user for minimal or no costs. Through a network of these NGOs, they have been able to achieve a country-wide distribution. Additionally they also partner with independent and chain clinics, who are willing to pay for a good quality product - as their key pain point is unavailability of quality products in the market.

9.5 Assessment and training of personnel

Considering the need for training of personnel to meet a large and growing population of PwDs, investments are also required in technology to assist personnel and parents with rehabilitation and integration of PwDs with society. This could be envisioned in the form of mobile applications for assisted learning for children with Autism Spectrum Disorder (Purnama et al., 2021). It could also assist communication, as exemplified by Ongtang & Thatphithakkul (2020, 2019) in their studies proposing a system for multi-party multi-modal communication assistance for persons with hearing impairment. To increase personnel to support AT provision, certification programs can be created with standard modules.

The Signable app connects deaf and mute users with the hearing population by offering real time interpretation services. The deaf user, when calling the app, is greeted by an interpreter using sign gestures in their preferred language (English/Telugu/Tamil etc.) who then dials the hearing member and speaks to them via audio and then translates everything into gestures, thus facilitating a two way conversation. Signable works with businesses as well as consumers at extremely affordable rates. Since the number of interpreters available in the country is drastically low, such a service allows users to get access on demand and at affordable rates.

9.6 Access and provisioning of AT

To improve access to AT for PwD, it is essential to ensure that the definition of disability used for eligibility of subsidies considers the widest spectrum of disabilities. The process of getting a disability card should be simplified. Awareness of disabilities in education programs must be included for all education levels.

For many PwDs, travelling to AT service providers is not an option due to costs incurred or the inability to navigate built environments. For others, due to the limited number of service providers for AT in SEAR, it is difficult to make routine visits. With the availability of mobile platforms and e-consultation systems, it is essential for PwDs to be able to access services such as remote consultations and have products delivered at the doorstep when required, thus reducing the emotional and social inhibitions of physically visiting AT service providers (Boot et al., 2021).

In high population zones such as SEA, discrepancies in data regarding the need for APs can derail funding pipelines and lead to unequal access to AT. Conventional methodologies for assessing the requirement of APs may need to be modified with rigorous verification to ensure clear targets can be set for procurement and supply chain requirements for APs (Boggs et al., 2021).

The nodal point of contact for PwDs, such as a village health volunteer, is crucial in improving access to healthcare, particularly in rural areas. A study in Thailand found that improving the competencies of the village health volunteers significantly improved the PwDs access to appropriate healthcare and AT (Nualnetr & Sakhornkhan, 2012).

9.7 Enabling technologies and innovation

Most assistive devices in SEAR continue to be obtained or appropriated from innovations in developed countries, thus providing little benefit to the bulk of the population which lives in very different geographical, cultural and technological environments compared to developed nations. These environments, with unique language, cultural and psychosocial requirements similarly need contextually relevant technology. While much of the developed world has adopted mobile technologies, and these technologies now have built-in accessibility features, they are not back-compatible with technology like print media. Making print media accessible for the visually impaired through, for example, a device to read out the text, can go a long way in ensuring that people do not need to make significant economic progress to be able to access the information and systems already available to them (Yadav & Kamthania, 2021). Similar innovations have been experimented which are rooted in SEA culture and ethnicity (Ambrogi et al., 2015; Dunque et al., 2021; Joy et al., 2020; Nizam et al., 2021; Sarker et al., 2020), such as the stand-up motorized wheelchair (Sulistiyawan et al., 2020), an application to translate sign language to Sistem Isyarat Bahasa Indonesia (Baehaqi et al., 2019), an assistive robot for management of multiple disabilities for the elderly (Motahar et al., 2019) modular wheelchairs for multifunctionality (Sarkar & Das, 2017), the electric powered wheelchair (Pearlman et al., 2009) and a multilingual augmentative and alternative communication tool for persons with severe speech and motor impairments (Ratnajit Mukherjee et al., 2010).

Suresh Kumar (name changed) has been using Flexmotiv crutches for more than a year now. He is a Ph.D. student in Delhi and has been using crutches of all kinds since the past 10 years and he can confidently say that he is not going back to traditional crutches. While he finds Flexmotiv crutches expensive at INR 2250 as all the other crutches he used were less than INR 2000 or he received them free through charity/ government distribution centers. However, prolonged usage of wooden or aluminum crutches leads to backache and fatigue. Flexmotiv's innovative anti-slip bottom that mimics the movement of the human foot makes it easy for users to continue using them for prolonged hours and in different terrains.

Contextually relevant products also find meaning in terms of user-centered design and local materials. A study by Bairagi & Mahajani, (2021) found the use of rattan cane for the development of a walker for the elderly, and the adoption of features like holders for newspapers and water bottles improved the functionality and user perception of the device. Sakib et al. (2015) experimented with solar energy as a means of powering electronic wheelchairs, and making them relevant to the context of PwDs in Bangladesh. Agarwal & Gautam (2014) propose an optimization of the lever propelled wheelchair as a more ergonomic and efficient approach to mechanically powering wheelchairs as compared with conventional push-rim and level wheelchairs.

The creation of contextually-relevant products, as exemplified above also needs relevant approaches to research and development. The expense of research and development for assistive devices for a market with little purchasing power is a substantial barrier, and typical R&D processes do not perform well. One alternative is a model proposed by Sujatha et al., (2021) for the R&D of high-quality yet affordable assistive devices for users in developing countries. The GRID (Grants Research Industry Dissemination) model aims to conduct R&D of assistive devices by identifying and applying for impact-oriented grants based in a nodal research organization, and use the expertise of industry partners for commercialization. By providing the product to users, user feedback can be obtained and disseminated to fulfil the needs of the grant of generating impact (Sujatha et al., 2021). Similarly, advancement in technologies has provided better methods for research into AT efficiency and effectiveness, particularly in rehabilitation and gait analysis for prosthetic users (Arelekatti et al., 2018; Giri et al., 2018).

New technology must focus not only on assistive devices but on the holistic concept of assisted living for people with life-long disabilities (Khasnabis et al., 2020). Improving older people's quality of life and allowing them to live independently at home rather than in nursing facilities is a major concern. The 100 smart cities programme in India can provide this service to individual houses. A smart home system may be created around unique socio-cultural and environmental challenges by utilising current technology within the homes of the elderly, as well as customising and linking familiar technologies from the person's experience (Triboan & Meggi, 2019). While most assistive devices continue to focus on regaining lost functionality, they are often not conceptualized for purposes outside of core functions. AT must also be used to develop self-care and recreational devices for the elderly to support a better quality of life (Maurya et al., 2019). This includes addressing the cultural and cross-cultural needs of an ageing population striving to live independent, fulfilling lives (Petrie et al., 2018).

In the 21st century, mobile phones and desktop computers have become ubiquitous in terms of the roles they play for all people. This is also to do with the multi-functionality these devices offer, ranging from information access and communication to mobility, education and management of data. This multi-functionality can be put to great use in supporting new AP, such as the computer based memory improvement tool for Dementia Alzheimer's patients proposed by Weerakoon et al. (2018) and the stroke rehabilitation application for LMICs proposed by Sureshkumar et al. (2015). The provision of AT in mobile phones greatly improves the independence and mobility of persons with visual impairment, particularly women, who have traditionally been forced to remain at home due to concerns of safety from the rest of the family (Pal & Lakshmanan, 2015).

The applications of AI have improved the usability of various AT, particularly in information and communication technology (Sharma, 2021). Teachers in higher education institutes have faced many challenges adapting to remote teaching during the COVID-19 pandemic. However, the use of video communication and education assistance platforms have not only provided comprehensive solutions to learning modules, but also provided inclusive platforms for PwD who could ordinarily not avail the benefits of classroom teaching (Sharma, 2021). Similarly, Joy et al., (2019) apply AI to the creation of a text-to-sign language converter for teaching sign language to persons with hearing impairments. Through a mobile application

this learning platform is made accessible to a broad section of the hearing-impaired community. Wellala et al. (2020) designed and tested a web-based learning platform which uses neural networks to detect facial expressions for children with down syndrome in special education centres in Sri Lanka to improve the children's communication and motor skills. Boppana et al. (2019) propose a sign language to speech converter for enhancing communication for deaf-and-dumb patients. Murad et al. (2019) proposed a smartphone application for persons with visual impairment to be able to identify Bangla currency using a deep-learning architecture for the recognition of bank notes.

The applications of new technology can also help leapfrog the limitations of current AT. Despite India accounting for over one fourth of the world's population of the visually impaired, the adoption of braille only accounts for a tenth of the persons with visual impairment. Furthermore, a knowledge of braille often limits the user's ability to read from information sources that can be touched. An example of leapfrogging technology would be to apply computer vision to read out text written at a distance, as exemplified by Arakeri et al. (2018).

Technological paradigms continue to evolve rapidly, providing diverse approaches to meeting the needs of PwD through AT. A review by Jafar & Nagesh (2021) identified signal-based, camera-based, gestural and motion based technologies among many others used to support the development of self-help device for quadriplegic patients. Desai et al. (2017) reviewed the advances in smart wheelchair technology, identifying use cases of computer vision, sonar, infrared, and dead reckoning among other technologies to develop autonomous, semi-autonomous and collision avoiding devices. Sait et al. (2019) propose a device utilizing GPS trackers and Bluetooth to help reduce the anxiety for dementia patients in India, and supporting care protocols with care givers rather than replacing them. The sheer diversity in the approaches indicates new possibilities for AT.

Research also indicates that caregivers and patients are becoming open to the use of novel devices for enhanced care outcomes. A study using focus group discussions with PwDs, caregivers, dementia care professionals and experts in robotics found that both care givers and patients are open to the use of social robots for assisting with dementia care. However, in this case, the sample was very small and so this is not a reflection of the society at large (Natarajan et al., 2021). Similarly, a study involving parents and care professionals of patients with Autism Spectrum Disorder found that parents were willing to adopt new technology in care protocols

(Ehsan et al., 2018). A study with caregivers for elderly in Thailand also found that caregivers were open to the use of passive and active intervention devices in smart homes for elderly (Visutsak & Daoudi, 2017).

There are various innovations that are already occurring frugally in the space of AT, but are rarely documented or developed into products for wider use. In their assistive technology assessment survey of 4254 adults in Bangladesh, Pryor et al. (2018) found that for people with functional disabilities, 46% had APs which were home-made, self-made or made by family members. Nanavati et al. (2018) presented a study in which an existing application called Speak-Up, which was used to gamify communication exercises for children with hearing impairments, found new applications through the users and was modified based on user feedback to support wider use-case scenarios and wider audiences. It is necessary to systematically identify these innovations and empower their creators to scale them for greater access among communities that may find use for the ideas and AP. Missions of the Indian government such as Start-up India and Smart India are some avenues to explore in motivating users of AT to propose new innovations to support the community.

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